A double-lined spectroscopic orbit for the young star HD 34700

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ABSTRACT

We report high-resolution spectroscopic observations of the young star HD 34700, which confirm it to be a double-lined spectroscopic binary. We derive an accurate orbital solution with a period of 23.4877 ± 0.0013 days and an eccentricity of $e = 0.2501 \pm 0.0068$. The stars are found to be of similar mass ($M_2/M_1 = 0.987 \pm 0.014$) and luminosity. We derive also the effective temperatures (5900 K and 5800 K) and projected rotational velocities (28 $\mathrm{km\,s^{-1}}$ and 22 $\mathrm{km\,s^{-1}}$) of the components. These values of $v \sin i$ are much higher than expected for main-sequence stars of similar spectral type (G0), and are not due to tidal synchronization. We discuss also the indicators of youth available for the object. Although there is considerable evidence that the system is young — strong infrared excess, X-ray emission, Li I λ6708 absorption (0.17 Å equivalent width), Hα emission (~0.6 Å), rapid rotation— the precise age cannot yet be established because the distance is unknown.

Subject headings: binaries: spectroscopic — stars: evolution — stars: individual (HD 34700) — stars: pre–main-sequence — techniques: spectroscopic

1. Introduction

Over the past decade numerous surveys of young stars in star-forming regions have found evidence that the overall frequency of binary and multiple systems is consistently higher than in the general field (e.g., Ghez, Neugebauer, & Matthews 1993; Leinert et al. 1993; Ghez et al. 1997; Ghez, White, & Simon 1997; Kohler & Leinert 1998; Simon et al. 1999), although the enhancement may vary somewhat from region to region (see, e.g., Simon, Close, & Beck 1999). In general those surveys have indicated roughly twice as many binaries as in the classical study by Duquennoy & Mayor (1991), which focussed on solar-type stars in the solar neighborhood that are typically much older. The results for the younger binaries refer

mostly to relatively wide systems (> 5 AU), spatially resolved by high-resolution imaging techniques such as infrared speckle interferometry or adaptive optics (see, e.g., Takami et al. 2003). Studies of binaries with smaller separations (spectroscopic binaries) in star-forming regions have not been as systematic, but may indicate a similar trend (see, e.g., Mathieu 1994; Corporon & Lagrange 1999; Zinnecker & Mathieu 2001; Melo 2003).

Partial lists of known spectroscopic binaries among pre–main sequence (PMS) stars have been presented by Melo et al. (2001), Prato et al. (2002), and others, and new binaries are slowly but continuously being added. More than two dozen of the systems with known orbits are double-lined spectroscopic binaries, which provide the most information on the individual masses of the components (compared to single-lined spectroscopic binaries).

The young star HD 34700 has recently been reported to be a double-lined spectroscopic binary by Arellano Ferro & Giridhar (2003), who also provided evidence of velocity variations. HD 34700 was originally identified as a young object from its strong infrared excess as observed by IRAS (Odenwald 1986; Walker & Wolstencroft 1988; Oudmaijer et al. 1992), a characteristic usually interpreted in terms of a circumstellar disk in other similar "Vega-excess" stars. It is located in Orion, although it is not clear whether it is associated with any of the star-forming complexes in the general vicinity. The optical, infrared, and millimeter-wave properties of HD 34700 have been modeled extensively by Sylvester et al. (1996) and Sylvester & Skinner (1996). They inferred that the disk has inner and outer radii of roughly 25–50 AU and 550 AU, respectively, depending on the model, and that the circumstellar material is composed mostly of relatively small dust grains (size $\leq 10\ \mu$m). Sub-millimeter observations have led to the detection of ^{12}CO and ^{13}CO emission, from which a total mass of $\sim$1 $M_{\oplus}$ in dust particles has been derived (Zuckerman, Forveille, & Kastner 1995; Coulson, Walther, & Dent 1998). Other estimates have varied between 0.2 $M_{\oplus}$ and 3.7 $M_{\oplus}$ (Sylvester & Skinner 1996; Walker & Heinrichsen 2000; Sylvester, Dunkin, & Skinner 2001), depending also on the assumed distance. Molecular hydrogen in the disk has been searched for, but not seen (Bary, Weintraub, & Kastner 2003). Low-level optical linear polarization has been detected by Bhatt & Manoj (2000) and Oudmaijer et al. (2001), consistent with a non-spherically symmetric distribution of dust (a disk). The infrared luminosity of the star is a considerable fraction of its bolometric luminosity ($\sim$8–35%; Zuckerman, Forveille, & Kastner 1995; Sylvester et al. 1996; Coulson, Walther, & Dent 1998; Bhatt & Manoj 2000; Sylvester, Dunkin, & Skinner 2001). As in other young objects, the Li I λ6708 absorption line is quite prominent in HD 34700, and the Hα line is seen in emission with highly variable profiles (Zuckerman 1994; Arellano Ferro & Giridhar 2003). It is also a strong X-ray source. The spectral type of the star has been listed as G0 (Odenwald 1986), or more recently as G0 IVe (Mora et al. 2001).

Given the interest in the object and the evidence that it may be a spectroscopic binary, the main motivation for this paper is to present high-resolution spectroscopic observations that indeed confirm its double-lined nature. From these observations we derive an accurate double-lined orbital solution. We discuss also the available indicators of youth.

2. Observations

HD 34700 (also HIP 24855, SAO 112630, IRAS 05170+0535, $\alpha = 5^{\rm h}19^{\rm m}41\overset{\rm s}{.}41$, $\delta = +5°38'42\overset{''}{.}8$, J2000, $V = 9.15$) was originally placed on our observing program at the Harvard-Smithsonian Center for Astrophysics (CfA) in 1996 as part of a project to monitor the radial velocities of several dozen nearby stars believed to be young from a variety of spectroscopic and photometric indicators (infrared excess, Hα emission, strong Li I λ6708 absorption, etc.). Observations were obtained mostly with an echelle spectrograph on the 1.5-m Wyeth reflector at the Oak Ridge Observatory (Harvard, Massachusetts), and occasionally also with a nearly identical instrument on the 1.5-m Tillinghast reflector at the F. L. Whipple Observatory (Mt. Hopkins, Arizona). A single echelle order centered at 5187 Å was recorded using intensified photon-counting Reticon detectors, giving a spectral window of 45 Å. The resolving power of these observations is $\lambda/\Delta\lambda \approx$ 35,000. The signal-to-noise (S/N) ratios range mostly from about 20 to 30 per resolution element of 8.5 km s^{-1}, with the exception of our first exploratory exposure.

That observation in March of 1996 clearly revealed the double-lined nature of the system from the double peaks in the cross-correlation function, despite being a very weak spectrum with a S/N ratio of only 7. The relative strengths of the peaks were similar, indicating stars of nearly equal luminosity. Once we realized this, exposure times were increased accordingly. Subsequent observations confirmed the double peaks, and we continued to monitor the star for another four years, obtaining a total of 35 spectra.

3. Radial velocities and orbital solution

Radial velocities were derived using TODCOR (Zucker & Mazeh 1994), a two-dimensional cross-correlation algorithm well suited to our relatively low S/N spectra. TODCOR uses two templates, one for each component of the binary, and combines one-dimensional correlation functions into a two-dimensional function that avoids the common blending problems of the standard procedures. The one-dimensional correlation functions were computed using

the IRAF[1] task XCSAO (Kurtz & Mink 1998). The templates were selected from a large library of synthetic spectra based on model atmospheres by R. L. Kurucz[2], computed for us by Jon Morse (see also Nordström et al. 1994; Latham et al. 2002). These calculated spectra are available for a wide range of effective temperatures ($T_{\rm eff}$), projected rotational velocities ($v \sin i$), surface gravities ($\log g$) and metallicities. Experience has shown that radial velocities are largely insensitive to the surface gravity and metallicity adopted for the templates. Consequently, the optimum template for each star was determined from grids of cross-correlations over broad ranges in temperature and rotational velocity (since these are the parameters that affect the radial velocities the most), for an adopted surface gravity of $\log g = 3.5$ (based on the system's probable pre–main sequence status) and solar composition. The values obtained are $T_{\rm eff} = 5900$ K and $v \sin i = 28$ km s^{-1} for the primary star, and $T_{\rm eff} = 5800$ K and $v \sin i = 22$ km s^{-1} for the secondary, with estimated uncertainties of $\sim$150 K and 1 km s^{-1}, respectively. These temperatures are consistent with the reported spectral type G0. We see no evidence in our spectra of the phenomenon of veiling, which is common in many other young stars and was reported by Arellano Ferro & Giridhar (2003) to be present in HD 34700. However, veiling can be variable.

Table 1 lists the radial velocities for both components, referred to the heliocentric frame. Typical uncertainties are given below. The stability of the zero-point of our velocity system was monitored by means of exposures of the dusk and dawn sky, and small systematic run-to-run corrections were applied in the manner described by Latham (1992). The accuracy of the CfA velocity system, which is within about 0.14 km s^{-1} of the reference frame defined by minor planets in the solar system, is documented in the previous citation and also by Stefanik, Latham, & Torres (1999) and Latham et al. (2002).

Following Zucker & Mazeh (1994), we have also determined the light ratio between the secondary and the primary of HD 34700 at the mean wavelength of our spectroscopic observations (5187 Å), which is close to the V band: $l_B/l_A = 0.80 \pm 0.02$. Arellano Ferro & Giridhar (2003) measured the equivalent widths of 105 relatively unblended lines in both components in one of their high resolution spectra, over the wavelength range 4260–6770 Å. The average ratio they found between the lines of the secondary and those of the primary is 1.00 ± 0.03. Since the stars are of very similar temperature, the line-strength ratio should be close to the light ratio between the stars. The Arellano Ferro & Giridhar (2003) value is somewhat higher than our own. We adopt in the following the straight average, $l_2/l_1 = 0.9$.

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[1]IRAF is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

[2]Available at `http://cfaku5.cfa.harvard.edu`.

A double-lined orbital solution was easily obtained from our radial velocities, showing a period of 23.5 days and a significant eccentricity. This orbit is shown graphically in Fig. 1, and the elements are listed in Table 2, where the symbols have their usual meaning. RMS residuals for the primary and secondary are 1.70 $\mathrm{km\,s^{-1}}$ and 1.34 $\mathrm{km\,s^{-1}}$, respectively. The slightly larger errors for the primary are explained by its higher value of $v \sin i$. Velocity residuals from our observations are listed in Table 1.

The heliocentric center-of-mass velocity we derive is $+21.03 \pm 0.18$ $\mathrm{km\,s^{-1}}$. This is in excellent agreement with the radial velocity for the CO material in the circumstellar disk measured by Zuckerman, Forveille, & Kastner (1995), which is +21 $\mathrm{km\,s^{-1}}$ (with a FWHM of 4.6 $\mathrm{km\,s^{-1}}$ for the $J = 1$–2 transition of CO from which the velocity was measured). We note also that this radial velocity is not far from typical values in the Orion star-forming region, which are about +25 $\mathrm{km\,s^{-1}}$ (although with a spread of several $\mathrm{km\,s^{-1}}$; see, e.g., Hartmann et al. 1986).

In reporting double lines for HD 34700, Arellano Ferro & Giridhar (2003) also presented their radial velocity measurements for both components based on the three high-resolution spectra they obtained. Those measurements are in fair agreement with our orbit, as shown in Fig. 1[3].

4. Discussion

As described in §1, there are fairly compelling indications that HD 34700 is a young object from a number of independent studies based on a wide variety of observational techniques. Zuckerman, Forveille, & Kastner (1995) considered the age to be ∼10 Myr or less, although based only on circumstantial evidence. The fundamental difficulty is that the distance to HD 34700 is essentially unknown, and therefore it cannot be placed on the H-R diagram and compared to model isochrones in order to estimate the age. The star was measured by the Hipparcos mission (ESA 1997), but the published parallax is rather uncertain ($\pi_{\rm HIP} = 0.86 \pm 1.84$ mas), and corresponds to a formal distance of 1160 pc. Assumptions on the distance to HD 34700 in the literature have ranged from 55 pc (Sylvester & Skinner 1996) to 90 pc (Coulson, Walther, & Dent 1998), derived by adopting absolute magnitudes and intrinsic colors from the spectral type, and accounting roughly for extinction. van den

[3]Examination of the individual velocities for each line in Table 2 of Arellano Ferro & Giridhar (2003) leads us to believe that the errors they quote in their Table 1 represent the scatter of the measurements rather than the uncertainty of the mean (which should be $\sqrt{N}$ smaller). If the smaller errors are adopted, then the agreement with our orbit for two of their velocities is considerably worse.

Ancker, de Winter, & Tjin A Djie (1998) adopted a lower limit of 180 pc, and Bhatt & Manoj (2000) relied on the Hipparcos determination.

Based on the light ratio of $l_2/l_1 = 0.9$ (§3) and the apparent system magnitude of $V = 9.15$ (ESA 1997), we infer individual magnitudes of $V_1 = 9.85$ and $V_2 = 9.96$ assuming there is no extinction. We may then use theoretical isochrones such as those by Siess, Forestini, & Dougados (1997) (see also Siess, Dufour, & Forestini 2000) along with our effective temperatures to compute the distance to each star assuming they are located on the zero-age main sequence (ZAMS), and adopting the solar value for the metallicity. This exercise results in distances of 122 pc and 125 pc for the primary and secondary, respectively. If the system were any closer, the stars would fall below the ZAMS in the H-R diagram. An extinction value of $A_V = 0.2$ changes these minimum distances slightly to 111 pc and 114 pc. Thus we conclude that the distance to HD 34700 is unlikely to be less than about 100 pc, and therefore that the smaller values adopted to infer properties of the system in most of the previous studies (which did not account for the binarity of the object, since it was not known at the time) are probably unrealistic. A parallax such as that corresponding to 100 pc (10 mas) is large enough that Hipparcos would most likely have been able to measure it accurately. A distance of 250 pc ($\pi = 4$ mas), on the other hand, is only about 2σ from the nominal value reported in the catalog, and could have been mismeasured. At this distance the age inferred from the above models would be about 9 Myr for both stars, in the absence of extinction. HD 34700 is located in Orion ($\sim$8° northwest of the belt), though it is not particularly near any of the more conspicuous star-forming regions in that area. Perhaps the closest connection that can be found is the similarity between its center-of-mass velocity and the typical radial velocities of other young stars in Orion, mentioned earlier[4]. Nevertheless, if we assume the star's distance to be the same as the main star-forming complexes, or $\sim$460 pc, the age inferred from the brightness would be as young as 3 Myr according to the model isochrones used above.

Despite the quite extensive studies of HD 34700 over the past 15 years, it is rather surprising that a measurement of the Lithium abundance —one of the key indicators of youth– has not been made until very recently. Arellano Ferro & Giridhar (2003) measured more than 100 spectral lines for both components of the binary, including Li I λ6708. The results were not mentioned explicitly in the text of their paper, but were reported in their Table 2 (available only in electronic form). The Li equivalent width for the primary (redward component in their spectra, according to our Fig. 3) is 0.0881 Å, and that for the secondary is 0.0790 Å. Examination of their Figure 2 suggests, however, that the Li line for the blueward

[4]The proper motion components reported both in the Hipparcos catalog and in the Tycho-2 catalog (Høg et al. 2000) are insignificantly small and are not of much help regarding membership in Orion.

component (secondary) may be blended with the Fe I λ6705.1 line of the redward component, in which case their Li equivalent width may be overestimated for the secondary. We adopt the measurements at face value. Correction for binarity using $l_2/l_1 = 0.9$ leads to final values of 0.17 Å for both components.

Equivalent widths such as these are not large compared to typical values in T Tauri stars, but HD 34700 is considerably hotter than most T Tauri stars. Lithium depletion is a strong function of temperature, and possibly also of rotational velocity. Comparison with diagrams of Li equivalent width vs. temperature such as those by Neuhäuser et al. (1997) (their Fig. 3), Alcalá et al. (2000) (Fig. 2), or Wichmann et al. (2000) (Fig. 1), and others, indicate that the stars in HD 34700 lie essentially on the upper envelope of the Pleiades distribution (age $\sim$120 Myr), and that the Li strength is not quite as strong as in stars in the younger cluster IC 2602 (age $\sim$35 Myr), which have equivalent widths of up to about 0.25 Å at these temperatures. We note, however, that if veiling were significant, as discussed by Arellano Ferro & Giridhar (2003), the measured equivalent widths for HD 34700 could be underestimated because the lines may be filled in by featureless continuum radiation. Therefore, the age of roughly 100 Myr or so is only an upper limit. Nevertheless, on the basis of the Li strength alone it is quite possible that the age is several tens of Myr instead of a few Myr, and therefore that it is not as young as some of the other evidence presented above would seem to suggest. As proposed by Fujii, Nakada, & Parthasarathy (2002), HD 34700 could be a young G star near the end of the T Tauri phase. From Fig. 5 in Alcalá et al. (2000) and using the effective temperatures we determined for each star, we estimate the abundance of Li as $\log N(\mathrm{Li}) = 3.1$–$3.2$ on a scale where $\log N(\mathrm{H}) = 12$.

HD 34700 shows Hα in emission, and the line profile changes significantly on very short timescales ($\sim$1 day), as illustrated by Arellano Ferro & Giridhar (2003). The equivalent width they measured is only 0.6 Å, which places it in the weak-line T Tauri class as opposed to the classical T Tauri group[5]. Profile variations in other lines have also been reported by Arellano Ferro & Giridhar (2003). Such changes are not uncommon in young stars.

The object is also a strong X-ray source, with a ratio of X-ray to optical flux of 4.3×10^{-4}. It is listed in the ROSAT All-Sky Survey Bright Source Catalogue (Voges et al. 1999) under the designation 1RXS J051945.3+053509, and its X-ray properties (flux, hardness ratios, etc.) are consistent with those of other young stars (see, e.g., Feigelson & Montmerle 1999).

The projected rotational velocity measurements we reported earlier (28 $\mathrm{km\,s^{-1}}$ and 22 $\mathrm{km\,s^{-1}}$ for the primary and secondary, respectively; §2) are quite close to those given by Arellano Ferro & Giridhar (2003) (25 $\mathrm{km\,s^{-1}}$ and 23 $\mathrm{km\,s^{-1}}$), although very different from

[5]A similar measure of the Hα emission ($\sim$0.2 Å) can be derived from Fig. 2 of Zuckerman (1994).

the $v \sin i$ of 46 ± 3 km s^{-1} determined by Mora et al. (2001). The latter value is based on two high-resolution spectra ($\lambda/\Delta\lambda$ = 49,000, slightly higher than the resolution of our own observations) taken at similar orbital phases of 0.67 and 0.72 (see Fig. 1). By chance one of our exposures was obtained on the same night as the first of the Mora et al. spectra. Fig. 2 shows that the lines in that spectrum are severely blended due in part to their intrinsic broadening, which explains the large $v \sin i$ measurement by Mora et al. (2001). The velocity separation at this phase is $\sim$40 km s^{-1}. At other phases the lines are clearly separated, as seen in the figure.

The $v \sin i$ values for the components of HD 34700 are relatively large, and one may ask whether they could be the result of tidal locking of the rotation with the orbital motion of the binary, which often goes together with orbital circularization in closer systems. The significant eccentricity of the orbit and relatively long period of 23.5 days seem to argue against this, although as a rule orbital circularization occurs on much longer timescales than rotational synchronization (see, e.g., Hut 1981). If the rotation period $P_{\rm rot}$ of each star were the same as the orbital period, the measured $v \sin i$ values and the relation

$$v \sin i = \frac{2\pi}{P_{\rm rot}} R \sin i \tag{1}$$

lead to values for the projected radii of $R_1 \sin i = 13.0$ R$_\odot$ and $R_2 \sin i = 10.2$ R$_\odot$. These seem much too large for PMS stars of this temperature. Even if the rotational period corresponded to the orbital motion at periastron ("pseudo-synchronization"), eq.(42) of Hut (1981) predicts a correction factor for $P_{\rm rot}$ of 0.72 at the measured eccentricity of HD 34700. The projected radii would then be $R_1 \sin i = 9.4$ R$_\odot$ and $R_2 \sin i = 7.4$ R$_\odot$, still too large in absolute terms by the time the increase due to the projection factor is accounted for. For comparison, at the distance of Orion (and an age of 3 Myr) the same theoretical isochrones used above predict sizes for the stars of about 4.4 R$_\odot$. Thus, the components in this system are spinning much more rapidly than synchronization would imply (at least twice as fast). This may perhaps be considered one more indication of youth, since main sequence stars of this spectral type do not usually rotate at more than a few km s^{-1} (e.g., Gray 1992).

Based on the PMS models by Siess, Forestini, & Dougados (1997) and assuming that HD 34700 is at a representative distance of 200 pc, we estimate that the absolute masses of the components are roughly 1.1–1.2 M$_\odot$, similar to what is expected for main sequence stars of the same spectral type. The minimum masses from our orbital solution (Table 2), in turn, imply an inclination angle for the orbit of about 50°. The semimajor axis is then 0.21 AU, which is well within the inner radius of the circumstellar disk as modeled by Sylvester et al. (1996) and Sylvester & Skinner (1996). At the same distance of 200 pc the angular semimajor axis would be 1 mas, difficult to resolve with current interferometers, although the eccentricity of the orbit would make the actual separation some 25% larger at certain phases.

If the system is at the distance of Orion, the masses inferred from the evolutionary tracks are about twice as large (and the orbital inclination angle $\sim$39°), the linear semimajor axis only slightly larger than before (0.26 AU), and the angular semimajor axis would be about 0.6 mas. Detecting the motion of the *photocenter* of the pair is far beyond the capabilities of the Hipparcos mission (initially we had considered the unmodeled photocentric motion as a possible explanation for the large error in the parallax). From the mass ratio and light ratio determined here, we estimate the semimajor axis of the photocenter to be only 2.3% of the angular semimajor axis of the relative orbit. This is mostly because the stars are of similar brightness, so their center of light does not move much. At the distance of Orion, the 14 μas signal would be challenging to measure even for NASA's Space Interferometry Mission.

Finally, we note that the Hipparcos epoch photometry (H_p band) shows no sign of photometric variability at the few milli-magnitude level over the duration of the satellite's 3-year mission, which is somewhat unexpected if the star is very young, but perhaps not so much so if it is already near the ZAMS. Similar evidence in the JHK bands was presented by Eiroa et al. (2001).

5. Concluding remarks

We have confirmed the young star HD 34700 to be a double-lined spectroscopic binary, and presented an accurate orbital solution with a period of 23.4877 days and a significant eccentricity ($e = 0.2501 \pm 0.0068$). The components are of very nearly equal mass, temperature, and luminosity. The measured projected rotational velocities indicate super-synchronous rotation in both stars.

We have examined the available indicators of youth, and find that when considered together, the following present fairly compelling evidence in favor of PMS status:

(a) Significant infrared excess suggesting the presence of a sizeable circumstellar disk. Polarization and CO measurements consistent with this idea. Large fractional luminosity in the infrared.

(b) Hα in emission, with a strength ($\sim$0.6 Å equivalent width) that places the object in the weak-line T Tauri class.

(c) Strong Li I λ6708 absorption (equivalent width 0.17 Å).

(d) Variable line profiles for Hα, and possibly other spectral lines. Possibility of veiling.

(e) Strong X-ray emission as seen by the ROSAT satellite, consistent with that detected in

other weak-line T Tauri stars.

(f) Rapid rotation of the components (28 $\mathrm{km\,s^{-1}}$ and 22 $\mathrm{km\,s^{-1}}$, $\sim$10 times faster than main-sequence stars of similar spectral type) in an orbit that is wide enough that the stars are not tidally synchronized.

(g) Location of the star in the general vicinity of the Orion star-forming region, and a radial velocity (+21 $\mathrm{km\,s^{-1}}$) fairly close to typical values for other young stars in that area.

It is difficult to estimate a precise age for the system due to the lack of an accurate parallax. If it is at the distance of Orion, theoretical isochrones indicate it is only a few Myr old. However, it could be closer and therefore be approaching the ZAMS, in which case the age could be several tens of Myr. The Li I λ6708 absorption is not quite as strong as seen in other very young stars, but the Li measurements for HD 34700 may perhaps be affected by veiling.

HD 34700 thus joins the relatively reduced group of a few dozen young spectroscopic binaries with known orbits, with its double-lined nature making it a particularly interesting case.

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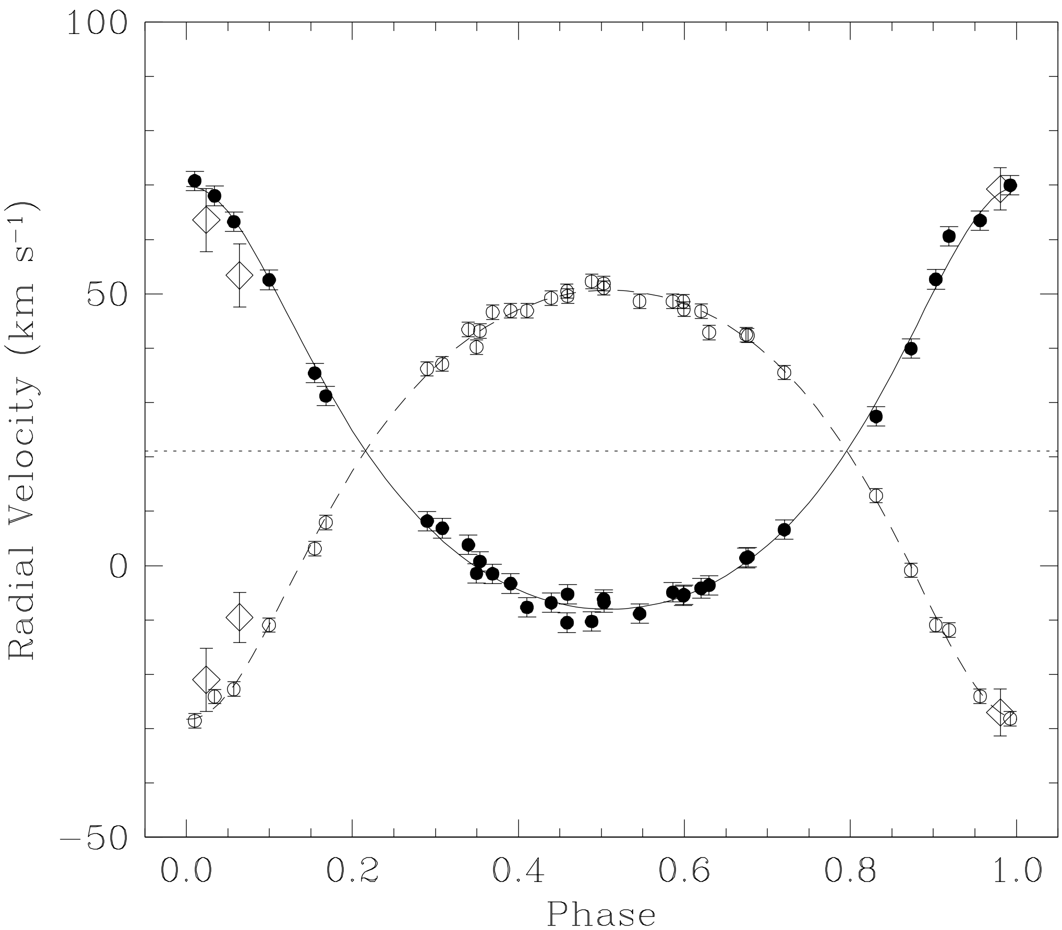

Fig. 1.— Double-lined orbital solution (solid curve for primary, dashed curve for secondary) along with our radial velocity measurements for HD 34000 (circles). Diamonds represent the measurements by Arellano Ferro & Giridhar (2003) (not used in the fit). Phase 0.0 corresponds to periastron passage, and the dotted line indicates the systemic velocity.

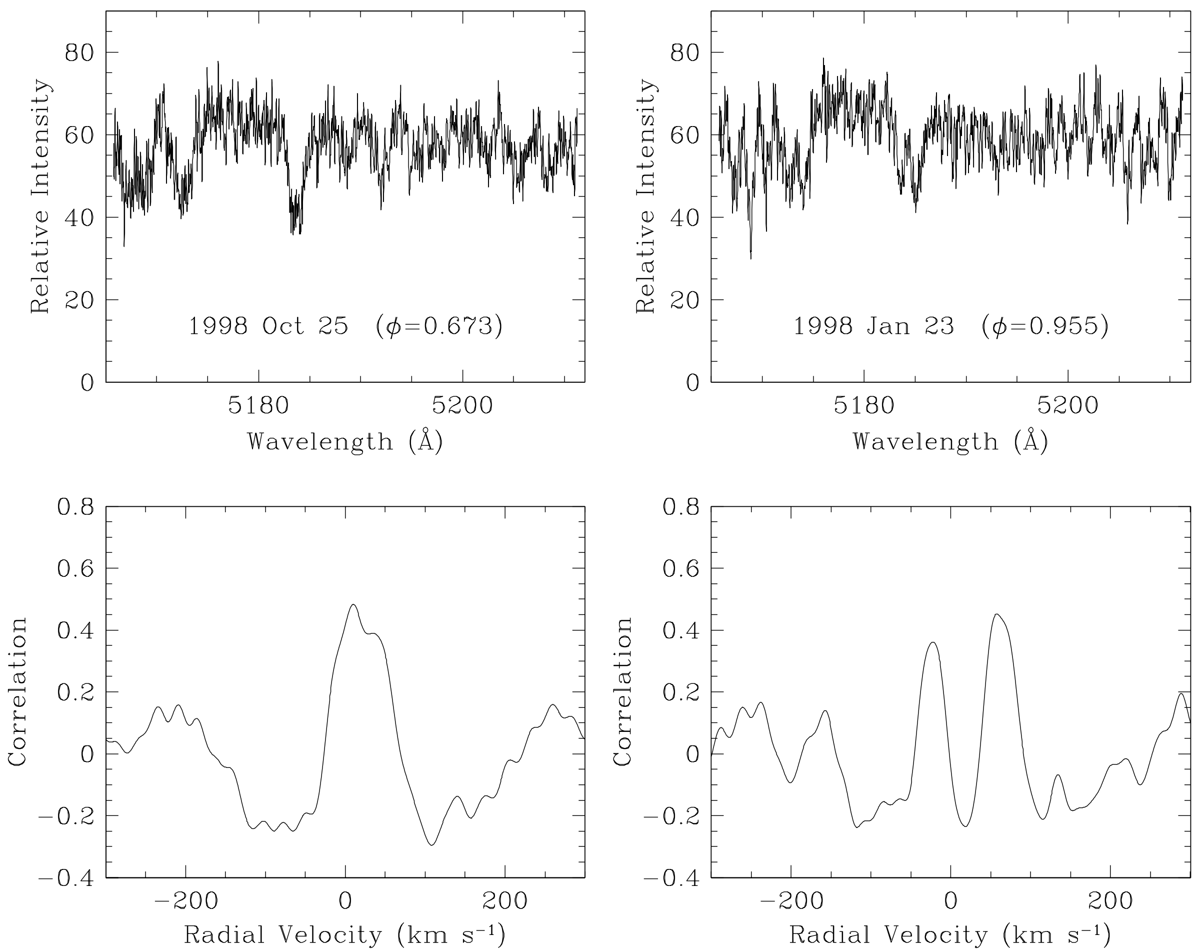

Fig. 2.— Left panels: Spectrum of HD 34700 and the corresponding cross-correlation function for our observation of 1998 October 25, showing that the correlation peaks for the two components are severely blended at this phase ($\phi = 0.673$; see Fig. 1). Coincidentally this is the same date as one of the observations by Mora et al. (2001), on the basis of which they reported a $v \sin i$ measurement of 46 $\mathrm{km\,s^{-1}}$. Right panels: Spectrum and correlation function for 1998 January 23 ($\phi = 0.955$), showing the correlation peaks well separated.

Table 1. Radial velocity measurements of HD 34700 (heliocentric frame).

HJD (2,400,000+)	RV_1 ($km\,s^{-1}$)	RV_2 ($km\,s^{-1}$)	$(O-C)_1$ ($km\,s^{-1}$)	$(O-C)_2$ ($km\,s^{-1}$)	Orbital Phase[a]
50154.6196	+59.90	−11.87	+4.30	+2.11	0.918
50382.7060	−3.56	+42.73	+0.06	−3.27	0.629
50411.9077	+39.65	−0.94	−2.34	−0.74	0.872
50448.7009	−6.86	+49.23	−0.20	+0.15	0.439
50710.8038	−5.50	+48.42	+0.17	+0.35	0.598
50729.8705	−7.53	+46.76	−2.33	−0.83	0.410
50752.8929	−3.27	+46.66	+0.61	+0.39	0.390
50781.7730	−4.28	+46.47	+0.04	−0.24	0.620
50804.7755	−5.30	+46.88	+0.32	−1.14	0.599
50836.6429	+63.33	−23.95	−1.40	−0.72	0.956
50845.6472	+3.74	+43.21	+3.00	+1.63	0.339
50854.5896	+6.32	+35.56	−0.28	−0.09	0.720
50872.6278	−10.28	+52.14	−2.31	+1.74	0.488
50900.5368	+1.28	+42.12	+0.47	+0.61	0.676
51061.8857	−8.74	+48.45	−1.06	−1.67	0.546
51080.8535	+0.67	+43.00	+1.39	−0.06	0.353
51102.8486	+8.04	+36.35	+0.86	+1.29	0.290
51111.8753	+1.39	+42.33	+0.83	+0.57	0.674
51126.7643	+6.68	+37.16	+2.11	−0.55	0.308
51154.8194	−6.11	+51.72	+1.97	+1.20	0.502
51174.7082	−1.56	+40.03	−1.25	−2.62	0.349
51198.6539	−1.54	+46.46	+0.62	+1.94	0.369
51240.5926	+35.28	+2.74	−1.44	−2.40	0.154
51467.8701	+28.09	+12.33	−1.86	+0.34	0.831
51522.7615	+31.40	+7.55	−1.58	−1.37	0.168
51542.5413	+70.80	−28.28	+1.34	−0.26	0.010
51544.6439	+52.37	−10.82	−0.28	+0.18	0.099
51566.5918	+67.81	−24.01	+0.33	+2.01	0.034
51576.5787	−5.35	+49.46	+2.02	−0.34	0.459
51577.6052	−6.70	+51.04	+1.38	+0.52	0.503
51590.6213	+63.32	−22.72	−0.16	−0.75	0.057
51610.4871	+52.42	−10.79	+1.36	−1.40	0.903
51612.5918	+69.90	−27.96	+0.61	−0.10	0.992
51623.5376	−10.50	+50.26	−3.15	+0.48	0.458
51626.5283	−5.03	+48.35	+1.28	−0.37	0.586

[a]Referred to the time of periastron passage.

Table 2. Spectroscopic orbital solution for HD 34700.

Parameter	Value
Adjusted quantities	
P (days)	23.4877 ± 0.0013
γ (km s^{-1})	+21.03 ± 0.18
K_1 (km s^{-1})	38.83 ± 0.42
K_2 (km s^{-1})	39.33 ± 0.34
e	0.2501 ± 0.0068
ω_1 (deg)	358.1 ± 1.6
T (HJD−2,400,000)[a]	51072.558 ± 0.093
Derived quantities	
$M_1 \sin^3 i$ ($M_\odot$)	0.531 ± 0.011
$M_2 \sin^3 i$ ($M_\odot$)	0.524 ± 0.012
$q \equiv M_2/M_1$	0.987 ± 0.014
$a_1 \sin i$ (10^6 km)	12.14 ± 0.13
$a_2 \sin i$ (10^6 km)	12.30 ± 0.11
$a \sin i$ ($R_\odot$)	35.12 ± 0.25
Other quantities pertaining to the fit	
$N_{\rm obs}$	35
Time span (days)	1472
σ_1 (km s^{-1})	1.70
σ_2 (km s^{-1})	1.34

[a]Time of periastron passage.